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ABSTRACT

Designed to be a guide for community action, this booklet examines issues and trends related to groundwater contamination. Basic concepts about groundwater and information about problems affecting it are covered under the categories of (1) what is groundwater? (2) availability and depletion; (3) quality and contamination; (4) public health considerations; (5) detection and monitoring; (6) federal legislation; (7) state and local legislation; (8) descriptions of three state programs; (9) community organizing efforts (including three examples); and (10) recommendations for citizen action. Appendices deal with how to have your water tested, additional information on legislation, suggested lists, and citizen organizations and contacts in most states. The booklet is one in the series of community action guides developed by Concern, Inc. (TW).

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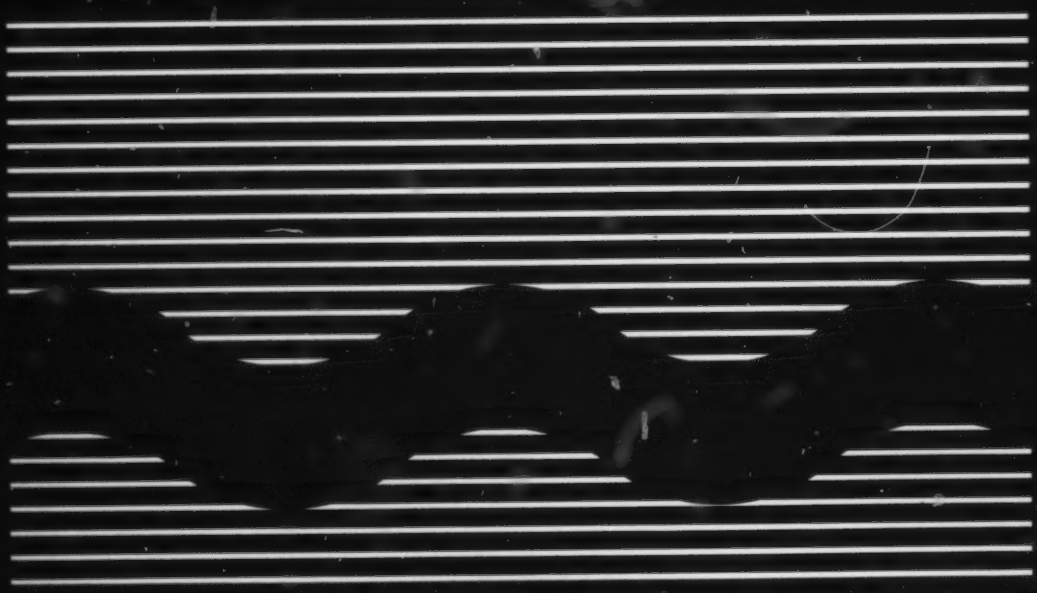
Groundwater



a community action guide

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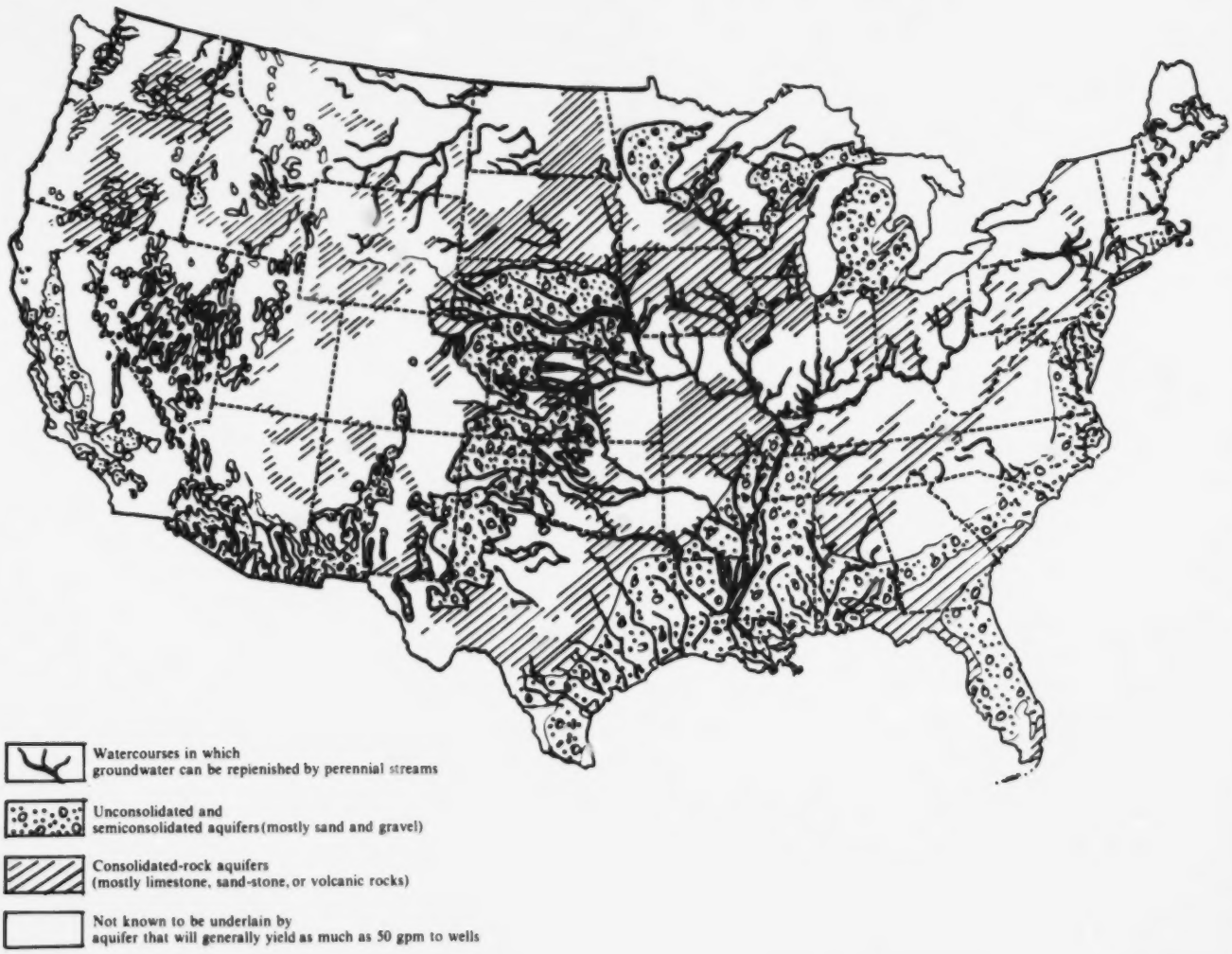
Major aquifers in the continental United States


Watercourses in which groundwater can be repienished by perennial streams
Unconsolidated and semiconsolidated aquifers (mostly sand and gravel)
Consolidated-rock aquifers (mostly limestone, sand-stone, or volcanic rocks)
Not known to be underlain by aquifer that will generally yield as much as 50 gpm to wells

Groundwater

a community action guide

CONCERN, INC.

This publication is made possible by grants from the Ruth Mott Fund, the Hillsdale Fund, and through the annual contributions of individual supporters.

June 1984

About This Booklet

In the United States almost half of us rely on groundwater for our domestic water needs. But, despite its importance to our lives and well-being, we are neglecting to manage this resource properly. In some areas serious depletion is taking place; in others, contamination from toxic chemicals, biological wastes, and other pollutants threatens groundwater supplies.

This booklet defines groundwater, the issues surrounding its use and misuse, and the urgent need for comprehensive management. It is the second booklet in Concern's series of community action guides. The first, *Hazardous Waste,* examines the extent of current improper management of hazardous materials. These booklets are intended to be used by individuals and groups everywhere as guides to gathering information and developing a local plan of action.

About Concern

Concern is a nonprofit, tax-exempt organization, founded in 1970, that provides environmental information to individuals and groups and encourages them to act in their communities. Concern publishes concise reports which define key environmental issues and contain suggestions for individual and group action. In many instances these reports have been the foundation for subsequent workshops, conferences, exhibits, and other educational activities. Concern's programs are supported by private grants and individual contributions.

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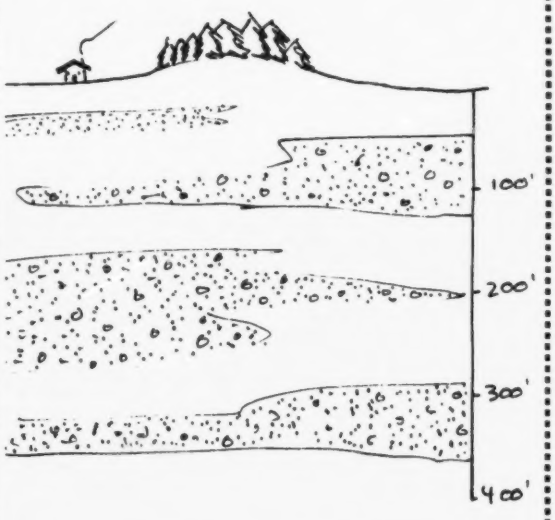
What is Groundwater?

Beneath the earth's surface lies our nation's greatest supply of fresh water. Representing 96% of our total water resources, groundwater constitutes the major source of drinking water for half our population. Once thought to be inexhaustible and safe from pollution, these reserves now face depletion and contamination. As instances of these problems are reported with increasing frequency around the country, public demand is mounting for improved management of this irreplaceable resource.

Many people envision groundwater as a series of lakes and rivers flowing beneath the surface of the earth and are surprised to learn that groundwater exists in permeable saturated zones of rock, sand or gravel called *aquifers*. These aquifers may cover only a few miles in overall area or they may extend over thousands of square miles—as does the Ogallala aquifer which reaches from South Dakota down to the plains of central Texas.



Cross-Section of Aquifers

Most groundwater originates as precipitation, percolates into the soil much as water fills a sponge, and moves from place to place along fractures in rock, through sand and gravel, or through channels in formations such as cavernous limestone. Constantly encountering resistance from the surrounding material, groundwater moves in a manner considerably different from that of surface water. Varying with the type of formation, its flow ranges from a fraction of an inch to a few feet per day. These movement characteristics are important to an understanding of groundwater contamination, since concentrations of pollutants called plumes will also move very slowly, with little dilution or dispersion.

"Unconfined" aquifers are the most susceptible to contamination. These aquifers are not protected by an overlying layer of impermeable material and may occur fairly close to the land surface. The volume of water available in unconfined aquifers will fluctuate with usage and with seasonal replenishment or "recharging" of the source by precipitation.

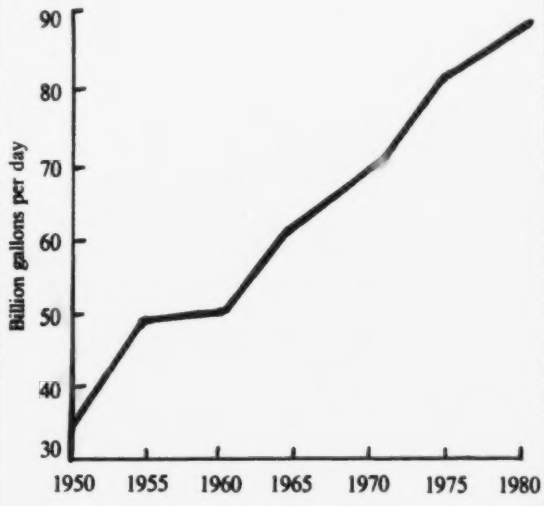
In contrast to this type of aquifer is the "confined" aquifer which is bounded on top and below by layers of relatively impermeable material. Confined aquifers generally occur at greater depths and their impermeable layers may offer a certain measure of protection from contamination. Some confined aquifers have no recharge zone at all and must be recognized as a finite resource which cannot be replenished.

Many types of human activities disrupt the natural equilibrium of an aquifer, affecting both the quality and the quantity of groundwater. Increased extraction of water in one area of an aquifer can affect availability in another; diversion of streams and draining of wetlands can change the location and amount of water absorption; paving for buildings, roads, and parking lots can prevent water from entering the soil and eventually recharging the aquifer;

changes in the type or amount of vegetation grown on the surface can alter water circulation, as can flooding or prolonged drought.

Population pressure, increased per capita use, and contamination of surface supplies have forced many communities to turn to groundwater. Estimates are that almost half the people living in the United States today rely solely on it for their domestic needs. Of course, people have been digging wells and pumping water out of the ground for centuries. It is the current scale of dependence on groundwater that is new.

More than two-thirds of all groundwater extracted is used for agricultural purposes, especially in Western states where farmers depend particularly heavily on it to irrigate their crops. Since 1960, groundwater withdrawals have doubled, creating severe problems of supply in many areas; contamination from industrial, agricultural, and commercial activities has rendered many existing supplies unusable.



Groundwater withdrawals in the U.S.

Source: U.S. Geological Survey

Percentage of population relying on groundwater

State	Total Users	Public Supply Users	Rural Users
Alabama	59	38	100
Alaska	63	49	74
Arizona	71	66	100
Arkansas	67	49	100
California	46	43	93
Colorado	23	16	87
Connecticut	37	24	98
Delaware	65	53	100
Florida	91	89	100
Georgia	70	38	98
Hawaii	87	95	14
Idaho	88	87	90
Illinois	38	36	82
Indiana	58	43	87
Iowa	82	75	100
Kansas	62	50	93
Kentucky	39	14	88
Louisiana	62	48	100
Maine	37	20	91
Maryland	30	12	100
Massachusetts	31	27	100
Michigan	38	20	100
Minnesota	67	55	100
Mississippi	90	85	100
Missouri	31	24	74
Montana	47	30	93
Nebraska	86	81	100
Nevada	64	60	97
New Hampshire	61	48	98
New Jersey	53	47	100
New Mexico	92	91	96
New York	32	25	100
North Carolina	60	25	99
North Dakota	66	48	99
Ohio	40	29	80
Oklahoma	40	28	85
Oregon	56	30	92
Pennsylvania	30	14	100
Rhode Island	33	25	100
South Carolina	61	18	100
South Dakota	79	69	94
Tennessee	51	38	100
Texas	58	50	100
Utah	58	53	99
Vermont	56	35	96
Virginia	34	14	98
Washington	44	38	78
West Virginia	53	32	97
Wisconsin	64	49	100
Wyoming	61	52	89
District of Columbia	0	0	0
Puerto Rico	26	17	80

Source: US EPA

Availability and Depletion

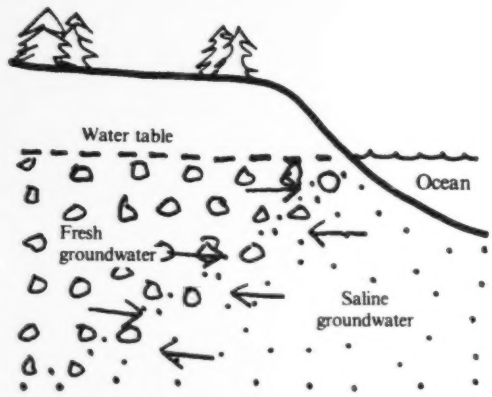
All states depend in varying degrees on groundwater resources. Arizona, Texas, Oklahoma, Kansas, Nebraska, Mississippi, Delaware, Hawaii, and Florida use more groundwater than surface water. Water consumption is expected to continue to keep pace with population growth in coming decades. If populations in the whole Southwest and the "sunbelt" states of Texas, California, and Florida expand, as census predictions suggest, the already stressed groundwater reserves in these areas could be depleted. With no change in management policies, severe shortages can be expected.

Availability is largely determined by geological characteristics and economic considerations. Climate also plays a role. In dry areas where annual precipitation is less than 10 inches, surface evaporation may exceed rainfall. In these areas and others where pressure from population and economic growth exists, groundwater depletion is a potentially critical problem.

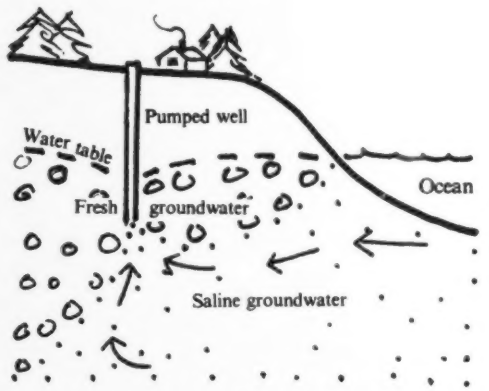
Groundwater depletion, longstanding in some areas and only now emerging in many others, is due to the overdrafting of aquifers, which means that the rate of water withdrawal exceeds the rate of recharge. This net extraction of water, particularly prevalent in the western and southwestern states, is often called "water mining," a practice that can eventually lead to depletion of an aquifer, or at least a lowering of the water table below the point at which extraction is economically feasible. When this occurs, groundwater ceases to be a renewable resource in that area. In those western states where a steady water supply is a matter of life or death for communities, the way in which groundwater resources are managed may spell the future economic fate of the entire region.

Exploiting a life-sustaining resource so as to bring about its eventual depletion is a serious problem in itself, but a number of other environmental problems also result. The lowering of the water table in an aquifer can make the aquifer more vulnerable to encroachment from outside bodies of water. This can be disastrous if the entering waters are saline, as in the case of sea water, or polluted, as is the case with many rivers and streams. Concentrations of salts, minerals, and other materials may increase to a level at which the aquifer is unsuitable for certain uses, such as drinking and irrigation.

Another serious side-effect of groundwater overdraft is land subsidence, which may occur when large volumes of water are extracted from an aquifer without sufficient recharge. Subsidence occurs because water pressure in the pores of the aquifer supports, to some extent, the weight of the overlying earth. When significant amounts of water are withdrawn, the decline in



NATURAL CONDITIONS
Stable relationship of fresh groundwater to saline groundwater in a coastal area



SALT INTRUSION
Salt water intrusion caused by reduction of fresh water aquifer

A sinkhole disaster in Florida

Photo: US Geological Survey

pressure allows the particles of rock to settle together slightly. Eventually this effect is transmitted over a large area to the ground surface and subsidence occurs. In Dallas and Galveston, Texas, such shifts have caused damage to buildings, roads, and bridges; in areas of California's highly productive San Joaquin Valley, subsidence of up to 30 feet has made the land more exposed to flooding and drainage problems; in urban areas like Phoenix, Arizona, damage to underground well casings, cables, and sewer pipes has decreased sewage flow capacity and increased maintenance cost. Subsidence also reduces the overall volume of the underlying aquifer so that even if recharge should take place former levels of supply could never be maintained.

The development of sinkholes, a natural phenomenon in areas containing soluble rock, seems to be aggravated by increased extraction of groundwater. More and more incidents of this have been reported: in Alabama, Georgia, Tennessee, and Florida in the Southeast; Pennsylvania in the East; and Missouri in the Midwest. Because these collapses happen suddenly, injuries as well as property damage are likely to occur. Introduction of pollutants from the surface may also contaminate the groundwater. Since the geological characteristics of most regions are known, and the amount of extraction quantified, sinkholes could be prevented.

Quality and Contamination

Groundwater naturally contains organic substances, minerals, sediment, bacteria, and viruses. Its properties (hardness, salinity, pH, turbidity, color, taste, and odor) can be measured by units of concentration. Depending on its intended use—domestic, agricultural, or industrial—recommended concentrations vary. When these concentrations are exceeded, the water is said to be contaminated. The degree to which aquifers are affected depends in part on geology, permeability of soils, climate, depth of groundwater, the type and intensity of human activities on the surface, and the interaction of contaminants as they percolate through the soil.

Natural contaminants include chlorides, radioactivity from uranium in the ground, arsenic such as that found in the thermal springs in the Northwest, and concentrated salts from heavy irrigation in arid areas and where the water table may be near the surface as in parts of the West and Southwest.

It is, however, man-made contamination from most of our "accepted" waste disposal practices that is responsible for the incidents of groundwater contamination throughout the United States. Primary pollution sources include:

- industrial impoundments
- land disposal sites
- septic tanks
- oil drilling
- mining
- municipal wastewater

Discarded chemical products, as well as wastes from their manufacture, end up in many of the 18,500 landfills spread across the nation. Wastes from smaller commercial enterprises (printers, dry cleaners, gas stations) are also disposed of in this manner, as is sewage sludge, a product of the sewage treatment process, which may contain heavy metals or organic chemicals. Across the country, toxic wastes which have leached from these municipal and industrial landfills are being discovered in underlying aquifers.

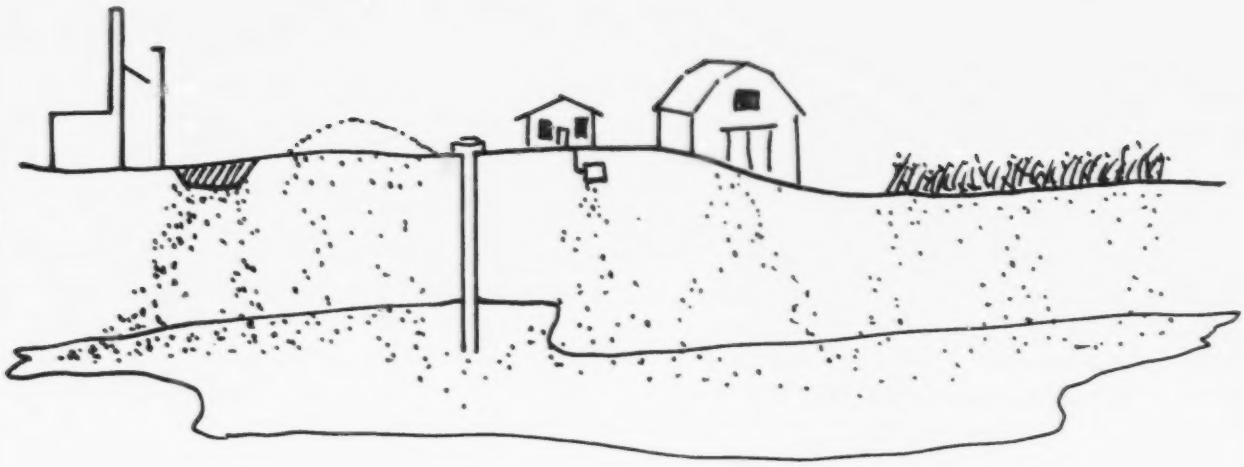
In addition to landfills, 180,000 wastewater impoundments (ponds, pits, lagoons) have been built to store wastes. About 23% of them contain hazardous substances such as heavy metals, oil, organic compounds, and pathogenic organisms. Often overlying aquifers, many of these sites are unlined and unmonitored.

Polluted water draining from a cattle feed lot

Human wastes from septic fields and livestock wastes from feedlots are also seeping into these underground areas. In agricultural areas, pesticides, herbicides, and fertilizers, thought until recently to break down in soil, are polluting both surface and groundwater.

Drilling and mining operations are also responsible for introducing contaminants into groundwater. In oil and gas production, for every barrel of oil extracted, 10 to 100 times as much brine is produced. Formerly this liquid was emptied into unlined pits. Now it is often injected deep into the ground. Once thought to be a fail-safe method of disposal, this technology is now being questioned as to its safety.

Spills from pipeline breaks and accidents in transportation contribute to the contamination problem. Acid mine drainage from coal and metal mining and radioactive waste from uranium mining, hospitals, utilities, and defense operations have contaminated groundwater in many states.



Aquifer contamination from industry, home and farm

Leakage from underground storage tanks (at gas stations and industrial plants) is also believed to be a major source of contamination. Huge quantities of salts used for de-icing roads in northern states are entering aquifers as well as surface water. The result of these two practices has been extensive contamination of thousands of wells affecting millions of people.

The potential gravity of this situation derives from the geological characteristics of aquifers. Unlike surface waters, aquifers are not visible. One cannot see or smell changes in them. No biological indications give a clue to alterations of quality. There is no early warning system.

Aquifers are not exposed to air or sunlight, nor do they have the free-flowing, self-oxygenating cleansing properties of surface water. Most water within the aquifers moves at an extremely slow rate so that if there is contamination, usually in the form of a plume, it spreads slowly and unpredictably. Pollutants tend to be more concentrated and, since there is little motion, may sink to the bottom and remain undetected by shallow monitoring.

A polluted aquifer is virtually impossible to clean. Preventing contamination is the only effective long-range solution.

Public Health Considerations

Microbial or chemical contamination of groundwater can result in disease and poisoning. Since the passage of the Clean Water Act of 1972, there has been a widespread decline in the presence of bacteria in both surface and ground waters, largely due to regulation of the effluent from specific point sources, such as sewage treatment plants.

In contrast, there has been a dramatic rise in the number and concentrations of toxics, in general, and of synthetic organic chemicals, in particular, in groundwater. These are generally colorless, tasteless, and odorless; expensive to test; unregulated and unmonitored. Even though the US Geological Survey in its 1984 study concluded that insufficient data exist to determine their full impact on groundwater quality and human health, it is known that many of these compounds are toxic, mutagenic, or carcinogenic and that water treatment does not necessarily remove them.

Although they are found in drinking water sources across the country, these synthetic

organic chemicals receive only minimal attention in the Safe Drinking Water Act—the *only* legislation that regulates water quality to protect human health. In fact, only 21 chemicals, of the thousands that exist, are included in the drinking water standards. With hundreds of new compounds being introduced into the environment each year, and more cases of contamination turning up, the regulation of these chemicals should be greatly accelerated.

Detection and Monitoring

A comprehensive monitoring system is part of sound groundwater management and central to the protection of human health. The United States does not have one.

Monitoring the water in aquifers on a regular basis can provide the data needed for trend analysis. Monitoring at waste disposal sites can track the presence of contaminants. Federal agencies such as the US Geological Survey and the Environmental Protection Agency—in addition to state water, geologic and health departments and public water suppliers—monitor groundwater in those situations prescribed by federal and state laws, but methods are limited and not coordinated. Furthermore, since so few maximum contaminant levels (MCLs) have been set by EPA, as prescribed by federal law, pollutants that have not been classified remain entirely unregulated.

Monitoring of the type, source, extent, and concentration of pollutants is made more difficult by the fact that, while moving down to the aquifer, substances can change chemically as they react with other substances in the soil. Testing, which must be done on an extensive and regular basis to be effective, is very expensive. Priorities are set within the restrictions of funding and personnel. At the same time, reporting of groundwater contamination and federal enforcement of standards has been limited. As a result, so little incentive exists for private industry and governments that voluntary compliance is now virtually nonexistent. In short, our failure to deal with groundwater deterioration only postpones and increases its eventual cost; only the will of the public can bring about government response.

Federal Legislation*

No one federal law or agency deals exclusively or even comprehensively with groundwater protection and management. Instead, numerous unrelated statutes address sources and types of contamination in very specific ways and with very few standards. Legally and administratively, these lack coordination. They generally deal with contamination after-the-fact, rather than with protection and prevention, and do not adequately identify the sources of contamination, leaving groundwater subject to diverse types of degradation.

Lack of commitment at the national level by Congress and the Executive agencies is reflected by inadequate funding, insufficient monitoring, poor regulatory follow-up, and lack of an overall legal framework with which to guide state and local policymakers and administrators. During the past years, the EPA has been devising and revising drafts of a national groundwater strategy. Its 1984 version primarily emphasizes guidelines (mostly organizational) for states to adopt, rather than the development of federal regulatory and enforcement capability. As a result, there are few incentives for states to protect aquifers, and little financial and technical assistance to carry out programs. Although internal administrative changes at the EPA are mentioned, integration of planning and implementation for water resources by all responsible agencies is not addressed.

*For a description of federal laws relating to groundwater, see Appendix.

Comprehensive management to protect our water resources is essential and should include:

- integrated management of surface and groundwater resources
- stringent regulation of the disposal of wastes
- comprehensive permit systems
- strong water conservation incentives
- land-use planning
- standards for the construction and operation of underground storage facilities and wells.

State and Local Legislation*

Traditionally, state and local governments have had the primary responsibility for groundwater use and protection; yet not one state has a truly comprehensive management system. In the absence of a federal model, each state has approached groundwater management with its own standards, regulatory mechanisms, and organizational structure, generally dividing the responsibility among two or more state agencies. Crisis-management, the usual response to groundwater problems, has proven totally inadequate and costly—a situation which may be the very stimulus needed to force states to consider the adoption of more foresighted

*For a description of state laws relating to groundwater, see Appendix.

"EPA has no coordination between setting standards under one program and correcting for those toxic requirements in other programs it regulates. Thus, the Toxic Substances Control Act (TSCA) enacted in 1976 regulates 53 substances which were tested and determined to be hazardous to human health. EPA under the Safe Drinking Water Act only regulates maximum contaminant levels of 21 substances. EPA has no apparent mechanism for forwarding the results of research from TSCA to incorporate in the Safe Drinking Water Act standards. This is just one example. There is little coordination between TSCA and the effluent guidelines established for industries under the Clean Water Act. The Resource Conservation and Recovery Act (RCRA) regulates 13 more substances than are controlled under the the Clean Water Act. There is no coordination between substances controlled in the water and airborne emissions under the Clean Air Act, such as benzene. The so-called manifest tracking systems were established under RCRA, but no system was established for the disposal of hazardous substances like PCBs regulated by TSCA. Finally, EPA has no way of identifying if an industry handling a hazardous substance is controlled by or has a permit under more than one regulatory program, such as RCRA, the Clean Water Act, Superfund, or the Clean Air Act. Often the facility is identified by its headquarters address, not the location of the actual discharge. This makes it hard to identify if a hazardous substance effectively controlled under one regulatory program is now being disposed of in another media; for example RCRA waste being disposed of into a sewer.

"Under such obvious lack of rudimentary coordination, it is clear that groundwater protection cannot be achieved and public health cannot be protected."

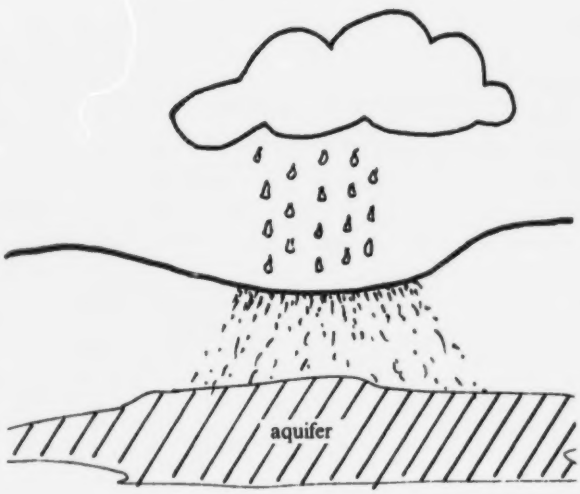
Brent Blackwelder
Environmental Policy Institute
excerpt from testimony to House Government Operations Committee, April 12, 1984

systems. States need an integrated plan within which to structure prevention, monitoring, and enforcement programs.

Today, state effectiveness is generally hindered by conflicting institutional and legal approaches and by the lack of adequate funding. In most states, agencies that control water allocation are not the same as those that oversee water quality, and neither of these groups may have regulatory or judicial powers. The many agencies that administer laws and regulations concerning groundwater protection range from health departments, natural resource commissions, and departments of environmental protection to water resource commissions, water management districts, and zoning boards. As a result, groundwater allocation policies have been established without regard for the maintenance of quality and vice-versa, or without consideration for the legal ramifications. The following situations can arise:

- A state draws up an aquifer classification system which permits an aquifer to degrade and allows a waste disposal facility to be constructed above it. Owners of neighboring wells then claim compensation from the state or facility for infringing on their water rights.
- In contrast, a community wishes to protect its aquifer by imposing strict zoning limitations in a designated area. Landowners within that area claim loss of property values.
- Or, a municipality allows a housing development above a critical recharge zone, thus impeding the return flow of water to the aquifer and potentially adding more sewage waste to it. This decision not only results in short-term expenditures for additional water treatment, but also in a need to find other water resources in the long term.

As groundwater becomes increasingly important to meet future water resource needs, state agencies need to integrate surface water, groundwater, and land-use policies.



Aquifer Recharge Area

Three State Programs

New Jersey residents recently passed one of the most stringent bills in the country to protect their groundwater supplies from increasing contamination. The Water Quality Bill of 1984 places responsibility on water suppliers to conduct more thorough testing and reporting of contaminants and requires the designation of maximum contaminant levels (MCLs) for a much broader spectrum of organic compounds. New Jersey also recognized the importance of an area with particularly high-quality and vulnerable groundwater, the Central Pine Barrens, by imposing a non-degradation policy for its underlying aquifers, effectively blocking industrial development and intensive land use in that area.

Similarly, **Florida** has acted to protect its critical recharge zones by employing zoning powers to limit activities in these areas. Here, shallow aquifers which supply over 90% of the population with its drinking water are in danger of pollution from leachates at hazardous waste sites and from pesticides in agricultural areas. Florida is also adopting a stricter groundwater

classification system and has increased the number of pollutants for which standards will be established. It has undertaken primary enforcement responsibility for underground injection of wastes and an aggressive program to control mining operations. Florida has also attempted to unify the administration of groundwater withdrawal near coastal areas to prevent ocean water intrusion into freshwater aquifers.

Irrigation on an Arizona farm

Typical of those states with a rapidly growing population and scarce rainfall, **Arizona** has had to decide between competing interests—from population growth, with its demands ranging from sewer systems to swimming pools, to industry and agriculture, which annually consume 89% of the state's water. In 1980, Arizona passed one of the nation's most extensive pieces of legislation for groundwater conservation, the Groundwater Management Act. With the goal of reducing per capita consumption 50% by 2025, this Act controls groundwater use through conservation plans for all water users, but most stringently for farming and industry in defined areas. In fact, the plan includes staged acquisition by the state of about half its agricultural acreage, the costs of which will be largely financed through pumping fees.

Community Organizing

Cape Cod

A successful approach to local comprehensive groundwater protection is demonstrated by the work of the Cape Cod Planning and Economic Development Commission. Because the Cape's sandy soil and high water table make its aquifers particularly vulnerable to contamination, in this case from commercial and household waste, the Commission developed a broad-based strategy to protect its drinking water. It began with establishing a regional comprehensive monitoring system. This included the purchase of equipment to test for the presence of chemicals in private wells, landfills, and public water supplies, with the intention of using the collected data as a basis for enforcement as well as for land use planning.

The next step involved a strategy to reduce the amount of hazardous material that could enter the ground. Businesses were required to register the type, amount, use, and storage of all their hazardous materials with the local Boards of Health. This information provided a better understanding of the location and quantity of chemicals being used. Follow-up inspections revealed improper methods of storage and transportation. Testing and standards for underground storage tanks were prescribed in order to detect and prevent leaks. Many Cape communities placed a ban on household use of certain pesticides and passed strict regulations for the installation of septic tanks.

To protect its sensitive recharge zones, a land acquisition plan was drawn up, partially funded by the state and by revenues from each property sale. Certain areas were also designated as sole-source aquifer regions under the federal program.

Throughout this process, public support was essential to its success and public education played a vital role in the passage of laws now used as models by other communities.

Long Island

Long Island is geographically similar to Cape Cod in that its soils are sandy, and deep aquifers serve as the primary source of drinking water for nearly all its residents. However, on Long Island, large-scale suburban development eastward from Brooklyn and Queens has taken place at a relentless pace over the last thirty years. Because there has been little or no planning for this growth, western Long Island has become a seemingly endless expanse of high-density subdivisions, shopping malls, highways, and parking lots.

The catastrophic consequences of this development pattern for the island's groundwater resources have only recently become apparent. Large-scale paving over of the land has greatly inhibited the capacity for rainfall to percolate through the soil and recharge the aquifers. The water that does enter the aquifers tends to be polluted with the inescapable by-products of urbanization—gasoline, lead, lawn chemicals, household cleaners, nitrates, and leachate from landfills.

The most significant residential development has taken place in the coastal areas, leaving commercial and industrial development to the central portion of the island where the major critical recharge areas for Long Island's water supply are also located. Due to this mistake in land-use planning, day by day, year by year, Long Island's water supply is becoming more severely contaminated. In fact, significant portions of the groundwater supply under western and central Long Island are already contaminated and/or overdrawn.

Until recently, it seemed that similar, unchecked development in eastern Long Island would quickly lead to the contamination of its aquifer, the area's last remaining supply of pure drinking water. Fortunately, in certain areas, citizen action succeeded in breaking this destructive pattern of laissez-faire growth. In the mid-1970s, residents of the South Fork, a region in eastern Long Island, became concerned about the implications of a building boom on their long-term drinking water supplies. Some instances of contamination had already occurred, most notably from leaking storage tanks in gas stations, improperly located landfills, septic systems, and agricultural use of pesticides.

Photo: The South Fork Land Foundation

The Group for the South Fork, a local environmental organization, investigated the issue. They concluded that population growth up to the levels permitted by the existing town plans would create a demand for water which would greatly outstrip the aquifer's safe yield and ultimately lead to serious depletion problems, and that water quality would continue to deteriorate if residential and industrial development were not carefully controlled. Fortunately, the critical recharge zones for the South Fork's aquifer lie in an area still almost completely free of development. Hydrological studies revealed that, in order to protect the groundwater from degradation, *no* development should take place in the recharge zones, and residential housing should be clustered in less sensitive areas. The group also found that population should be held down to 90,000. If there had been any doubt as to the validity of these findings, a federal report which came out shortly afterwards confirmed these conclusions.

In 1982, the Group for the South Fork set out to educate their communities and their local officials. They found that few people, in or out of government, had given much thought to the impact of population growth and poor land use planning on drinking water quality and quantity. The group began printing ads in local newspapers to publicize the problem. They published a booklet explaining the technical

issues and their policy recommendations. Gradually an informed public began to support groundwater protection.

Finally, the group began to press for action from local governments. With much of the community united in agreement, they achieved results remarkably quickly. In March, 1983, the town of Southampton rezoned 26,000 acres, about one-third of the town's unincorporated land, from two-acre-minimum lot size to five acres. Shortly afterward, the citizens of East Hampton voted out their aggressively pro-development town council, while voting in a new government which promised to protect the town's environment and drinking water.

The rezoning of residential acreage and the use of strict land-use controls hold great promise as tools to assure an adequate supply of clean groundwater for the future. Other protective measures include "watershed overlay districts" which limit the amount of chemical-dependent lawn turf which may be planted over the groundwater. New rules require gas stations to install improved underground tanks to minimize gasoline leaks. A new state law requires all landfills to be capped and closed by 1987.

It is to be hoped that these landmark changes will be adopted elsewhere in the region so that Long Island's last unpolluted groundwater reserves may be safeguarded for future generations.

Silicon Valley

In 1982, upon discovering a concentration of health problems in their community, residents in "Silicon Valley," an area of concentrated high technology plants south of San Francisco, began to question the quality of their drinking water and its health effects. Chemical leakage from underground storage tanks was thought to be responsible, even though at that time high technology was considered an environmentally "clean" industry. Those residents employed by the "high tech" companies formed worker safety committees and pressed for public disclosure concerning identification and storage of the chemicals. When investigations revealed that over 90% of the tanks leaked, labor and citizen groups joined forces to press for legislation. A model ordinance was drawn up which required:

- Secondary containment for all storage facilities
- Strict monitoring and leak detection provisions
- Reporting of all leaks and spills
- Comprehensive listing of chemicals needing to be regulated
- "Right-to-know" provisions
- Permit fees

Over 30 local governments adopted ordinances and, in the fall of 1983, despite heavy opposition from the electronics industry and oil companies, a state Groundwater Protection Bill was passed.

Location of underground chemical leaks and spills in Santa Clara County, as of March, 1983.

Citizen Action

Do you know the origin of your drinking water? The source may be as close as your home or hundreds of miles away.

If you are relying on public water supplies, you may be using groundwater or surface water, or both. If you have your own well you know that you are using groundwater. What do you know about the aquifer supplying that well?

To find out the exact source and quality of your public drinking water, contact your local Department of Environmental Services or your private water supplier. If you have a well, have your water tested.* A map of your aquifer or aquifer systems may be available from the US Geological Survey's District or Regional offices, located within the Department of the Interior. Determine who may be using, polluting, or drinking your water supply.

Many citizen organizatons are working on groundwater resource problems. The more informed you are, the better able you will be to ensure that you and your community are drinking clean water.

Get to know your aquifer or aquifer systems

- How extensive an area does it cover?
  - What jurisdictions does it cross?
  - How many citizens does it serve?
  - What percentage is used residentially, commercially, or industrially?
- Where are its critical recharge zones?
  - How is the land used above them?
  - How permeable is the soil?
- How much water is pumped out each year relative to its recharge?
  - What is the "safe yield" for this aquifer or aquifer system?
  - Has the water table dropped during recent years?
- Has your aquifer been mapped for its location, overdraft, and vulnerability to contamination?

Determine whether there are potential or existing threats to your groundwater

From agriculture:

- Has the level of nitrates in your water been tested?
- Are pesticides used widely in your area?
- Is there pesticide spraying on rights-of-way, Federal lands, municipal parks?

From industry:

- Are there any known toxic dumps overlying your aquifer or aquifer system?
- Are there, or were there, any factories which produced or used toxic substances in your region?
- Do you have any high technology firms in residential areas which are storing chemicals in underground storage tanks? Are they located over an aquifer?
- If there is oil and gas drilling, are these activities carefully regulated to prevent groundwater contamination?
- What provision is made for brine disposal?

* See Appendices

From households:

- What proportion of residents use septic tanks? What are the specifications for their use, installment, and monitoring?
- What provisions are made for the safe disposal of household pesticides, oils, paints and solvents?

From urban activities:

- Are your local gas stations monitoring for possible leaks from their storage tanks?
- Do you know how gas stations dispose of their used motor oil?
- How do the local dry cleaners, printers and other small establishments store, transport, or otherwise dispose of their toxic substances?
- If de-icing salts are used in winter in your area, are they stored carefully and applied sparingly?

From government planning:

- Is projected population, industrial, or agricultural growth threatening to strain your water supplies?
- Is there adequate planning in your region to balance water supplies fairly among competing sectors?
- Are there conservation programs to eliminate wasteful use of water in all sectors?

Find out how your groundwater is managed

- What agencies are responsible for your state and local water resource planning? How many personnel are involved? What is the funding level of the operations? What is their capability for monitoring and enforcement of water regulations?
- What substances are tested in your water? By whom? How is the information made known to the public? Is the record-keeping sufficient? Is the equipment adequate?
- How are the activities of these various agencies coordinated? Is there one central agency?
- How much technical assistance is there from the regional EPA?

Learn what your state and local governments are doing to protect your groundwater

- Is there an aquifer classification system?
- Have any aquifers been designated as "sole source?"
- How is the disposal of hazardous wastes controlled?
  - How is underground waste injection regulated?
  - Have siting standards for the land disposal of hazardous wastes been developed?
  - Is the production, handling, and disposal of chemicals closely monitored? Do companies have to register their use of chemicals with the Department of Health?
- Are there standards for underground storage tanks/well casings/well construction?
- Have land use controls been adopted?
- Are the safe drinking water standards stricter than the national standards? Are there standards for additional contaminants?
- How is depletion controlled?
  - Are there appropriation codes for groundwater allocation?
  - Is groundwater mining prohibited?
  - Is there a program of artificial groundwater recharge?
- How effective is the enforcement of regulations?
- Does the state have a compensation structure in effect for those adversely affected by contaminated and/or unavailable water?

- To what extent is public participation institutionalized in groundwater management decision-making?
- Have local governments adopted model municipal ordinances for groundwater protection?
- Are there established emergency plans for use in instances of spills and other types of contamination?

Make the issues known

Having established a sound data base on the sources and vulnerability of your groundwater, hold meetings, educate the media, write letters to the editor of your local newspaper, and inform your elected representatives of your concerns. Build a constituency to promote:

- appropriate land use controls
- registration of chemicals used by local industry/commerce/agriculture
- "right to know" legislation
- publication of violations of drinking water standards
- reduction of the production of toxic wastes
- containment standards for underground storage tanks
- regulation of chemicals
- model ordinances for groundwater protection
- comprehensive monitoring of aquifers
- conservation of water resources
- planning for growth
- funding of public intervenors who can represent citizen cases

How to Have Your Water Tested

If your water comes from a private well, you can ask your local health authorities to test it. However, as these tests can be extremely expensive and public funds for such purposes are generally quite limited, the chance of your request being acted upon is considerably enhanced if you can show that there is reason to believe that your water is contaminated. Has there been a high rate of illness among your neighbors? Are there landfills, chemical factories, or farms that use large amounts of fertilizers or pesticides nearby? Do you live in a heavily industrialized area? Have there already been instances of serious groundwater pollution in your state? If any of these situations is true, your case for getting your water tested is stronger.

> It has been proposed that a National Hot Line to provide information about tests which have already been conducted in various areas, as well as names of certified laboratories, be set up at a national level.

Send away to the EPA Office of Drinking Water for the most recent federal pollutant standards, and to your state agency for state pollutant standards (see State Resource List).

The water quality test results will probably include pre-and post-treatment figures. It will be divided into:

- organic chemicals, subdivided into trihalomethanes and pesticides;
- inorganic chemicals, including metals;
- arsenic, and other such elements;
- radioactive particles;
- microbiological contaminants.

It will also probably contain information on dissolved oxygen levels, turbidity, pH factor, temperature, chlorine, and fluoride. Most contamination levels will be given in mg/1, which represents a "parts per million" or ug/1, "parts per billion." Compare the concentrations given in your test print-out with official standards.

If you ascertain that your water contains contaminants, the next step is to analyze their source. You can use the Community Action Guide to develop a plan.

Federal Laws

SAFE DRINKING WATER ACT of 1974 contains the following sections that deal directly with groundwater:

Underground Injection Control Program (UIC)—intended to protect drinking water sources from underground injection of toxic waste by requiring state permits for such facilities and by strict monitoring of them.

The law does not:

- eliminate injection near or into drinking water quality aquifers;
- adequately provide for careful monitoring to insure the safety of the current technology and the possibility of contamination through leaks;
- apply to the disposal of oil, natural gas, and brine from oil and gas extraction;
- contain bonding and liability provisions as do other waste disposal practices under RCRA.

Sole Source Aquifer Program—addresses those aquifers that serve as the principal drinking water source for the majority of a community. It prevents a federally funded project from initiating any activity which might contaminate these water reserves.

The law does not:

- include federal programs such as water development projects undertaken by the Corps of Engineers, the Department of the Interior, and other government agencies;
- provide federal and state assistance for the designation of sensitive recharge zones and strict control for their protection.

Drinking Water Standards—set to assure the quality of drinking water supplies by determining certain maximum contaminant levels (MCLs) for specified pollutants in most, but not all, public water supplies. These standards are the minimum requirements that must be met in order for a state to assume primary enforcement responsibility, but states may adopt stricter ones.

The law does not:

- cover all water supplies;
- control all pollutants or require EPA to accelerate standard-setting for additional pollutants. (EPA has detected more than 700 synthetic organic chemicals in public drinking water supplies and yet current standards cover only *seven*);
- provide adequate monitoring and reporting;
- require comprehensive testing by public water suppliers or prompt notification to customers as to their findings (a study in 1983 revealed that 29% of municipal water wells in the U.S. contained toxic chemicals).

RESOURCE CONSERVATION AND RECOVERY ACT of 1976 (RCRA)—designed to protect groundwater, as well as other resources, from contamination by the improper treatment, storage and disposal of solid wastes. Through its 'cradle to grave' monitoring system, RCRA aims to end irresponsible dumping practices. Subtitle C expressly aims to prevent toxic leachate contamination from landfills and other surface impoundments, land treatment facilities, tanks, injection wells and others. Subtitle D prohibits a solid waste disposal facility from polluting a subsurface source of drinking water beyond its boundary.

The law does not:

- adequately regulate small generators of hazardous waste;
- regulate underground chemical storage tanks;
- include all hazardous waste, e.g. many carcinogenic wastes;
- adequately control land disposal facilities through strong siting codes, monitoring, construction, and eligibility of types of wastes for disposal.

CLEAN WATER ACT of 1972—provides limited authority for groundwater protection. Section 208, the main section affecting groundwater quality, covers the management of waste treatment. Other sections regulate the setting of state water quality standards and point source discharge. (Ironically, this Act, by controlling point source discharge into surface waters, has diverted wastes to land disposal, and thereby has subjected groundwater to additional contamination.)

The law does not:

- provide adequate regulatory powers;
- require the identification and clean-up of heavily contaminated waters;
- provide effectively for the control of non-point source pollution.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT of 1980 (CERCLA or "Superfund")—seeks to clean up and prevent the release of toxic materials from hazardous waste disposal sites. It addresses the prevention of groundwater contamination through the funding and implementation of remedial action.

The law does not:

- give a clear definition of what "effective" remedial action is;
- require sufficient taxation of industries that produce hazardous waste;
- provide technical assistance to citizens groups;
- include health studies and exposure assessments at sites;
- provide for emergency relief to those suffering from exposure to contaminants;
- update the hazard ranking system to accurately reflect possible effects on natural resources.

Other federal legislation which directly or indirectly affects groundwater: TOXIC SUBSTANCES CONTROL ACT (TSCA) of 1976; SURFACE MINING CONTROL AND RECLAMATION ACT of 1977; FEDERAL INSECTICIDE, FUNGICIDE AND RODENTICIDE ACT (FIFRA) of 1972 (amended).

State Laws

Groundwater quality is addressed by the following types of state laws:

- Laws which regulate **discharging sources.** These laws address the problem of point source pollution, including solid and hazardous waste facilities and underground injection wells as well as septic systems, fuel and chemical storage tanks, salt storage, and water detention basins.
- Zoning laws which control **land use.** These address non-point source pollution by restricting the location of potentially contaminating activities to a defined area; limiting development which might reduce the natural recharge of aquifers; and controlling the location and number of septic tanks in a given area so as not to exceed the natural assimilative capacity of the soil. Some provide for the actual purchase of land to preserve critical recharge areas.
- Laws which require **standards for contaminants** not covered by the national Safe Drinking Water Act.
- Laws which implement **aquifer classification.** These set water quality standards according to the projected use of the aquifer; e.g., drinking, irrigation, etc. They are being increasingly used by states to assure long-term availability of water reserves. Consideration is given to difference in existing water quality and geological characteristics that contribute to the vulnerability of the aquifer. Three main classifications have been considered by states:
  1) maintenance of aquifer quality at drinking water levels;
  2) prevention of further degradation for those aquifers with some contamination;
  3) in some cases, allowance for further degradation up to an established level.

  This system helps focus limited state resources on both planning and enforcement activities. Since aquifers cross state boundaries in many cases, consultation with neighboring jurisdictions is a prerequisite to success in standard-setting. The disadvantages of aquifer classification involve not only the political difficulty of choosing certain areas for waste discharge, but also the undervaluing of portions of groundwater resources, thereby allowing or even sanctioning degradation of the water.
- Laws which give the public the *right to sue* for property and/or personal injury. These can be applied to injury caused by groundwater contamination, as in the case of pollution of wells, but this is a costly, after-the-fact response to a problem and has limited effect as a deterrent.

Regulation of groundwater withdrawal and resolution of conflicts between competing demands generally come under the following rules, all modified from the original English rule of absolute ownership, which gave the landowner the right to withdraw water beneath his/her property, regardless of possible effects on neighboring property:

- **Reasonable Use Doctrine,** under which a landowner is permitted to withdraw water for reasonable and beneficial purposes.
- **Correlative Rights Doctrine,** which requires a landowner to coordinate withdrawal with neighboring withdrawal needs. Any surplus may be exported to other areas.
- **Prior Appropriation,** the method employed in some western states in which surface and groundwater is allocated according to "first in time, first in right" principles. Permits define both the amount of groundwater to be withdrawn and its intended use. Because individuals do not want to risk losing their allotment by not using their full quota each year, this rule tends to encourage wasteful practices.
- **New Well Permit Requirements,** used by some states to regulate the withdrawal of water. Consideration is given to the capacity of the underlying aquifer, and competing uses for it. In a few states, drilling is prohibiting in certain critical areas where depletion problems exist or are anticipated.

Interstate and Regional Commissions

Because aquifers and river systems cross state boundaries, several interstate groundwater management alliances have been formed. The Delaware River Basin Commission and the Susquehanna River Basin Commission, established by both state and federal law, focus their activities mostly on assessment, development, and allocation of the groundwater and surface water resources in their respective multi-state regions. These commissions have power to regulate and license; authority to finance, construct, and maintain water resource projects; and license to appropriate water among participating states. They also provide technical services to states for a variety of activities, such as water resource management, water quality, and project evaluation.

The High Plains Study Council, concerned with the Ogallala multi-state aquifer, is one of several special study groups which offers fundamental technical information and management. Though authorized solely to study and recommend, the Council has effectively served to promote action and coordinate the activities of affected states.

Recommended Reading

An Annotated Groundwater Bibliography. Massachusetts Audubon Society, Lincoln, MA 01773. $5.00.

Blackwelder, B. and Pl. Carlson. *Survey of Water Conservation Programs in the Fifty States: Model Water Conservation Program for the Nation.* Washington, D.C.: The Environmental Policy Institute, Aug. 1982. (Available from EPI, 218 D St., SE, Washington, D.C. 20003. $5)

Directory of Groundwater Programs and Activities of the Federal Government. Washington, D.C.: U.S. Department of the Interior, Office of Water Policy, Feb., 1983. (Available from the National Technical Information Service, Springfield, VA 22161)

Groundwater Management: Discussion of Issues. Report of the Interstate Groundwater Management Task Force. Washington, D.C.: U.S. Water Resources Council, Sept., 1981. (Available from NTIS, Springfield, VA 22161)

Groundwater Protection: A Citizen's Handbook, Natural Resources Defense Council, 1984.

Groundwater Protection Strategy, Environmental Protection Agency, 1984.

Groundwater Protection: A Guide for Communities, (Available from the Metropolitan Area Planning Council, 110 Tremont St., Boston, MA 02108)

The Nation's Water Resources. 1975-2000. Volume 1: Summary. Washington, DC: U.S. Water Resources Council, Dec. 1978. (Available from NTIS, Springfield, VA 22161)

National Water Summary, 1983 - Hydrologic Events and Issues, US Geological Survey. Water Supply Paper 2250. (Available from the US Government Printing Office.)

Patrick, Ruth, Veronica I. Pye, John Quarles, *Groundwater Contamination in the U.S.,* University of Pennsylvania Press, Philadelphia, 1983.

Powledge, Fred, *Water, The Nature, Uses, and Future of Our Most Precious and Abused Resource,* Farrar, Straus, Giroux, New York, 1982.

Rogers, Peter, "The Future of Water," *The Atlantic Monthly,* July, 1983.

Selig, E.I., *An Overview of Laws Dealing With Groundwater,* A speech prepared for the 6th National Groundwater Quality Symposium of the National Water Well Association in Atlanta, GA, Sept. 22, 1982.

Tripp, James and Adam Jaffe, "Preventing Groundwater Pollution: Towards a Coordinated Strategy to Protect Critical Recharge Zones," *Harvard Law Review,* Cambridge, MA.

"War over Water: Crisis of the 80's", *US News and World Report,* Oct. 31, 1983.

Citizen Organizations

The following organizations have regional offices and may be active on groundwater issues in your area:

Clean Water Action Project
733 15th St., N.W. #1110
Washington, DC 20005
(202) 638-1196

Environmental Defense Fund
444 Park Avenue South
New York, NY 10016
(212) 686-4191

Friends of the Earth
1045 Sansome St.
San Francisco, CA 94111
(415) 433-7373

Izaak Walton League
1701 N. Fort Drive #1100
Arlington, VA 22209
(703) 528-1818

League of Women Voters
1730 M St., N.W.
Washington, DC 20036
(202) 429-1965

National Audubon Society
950 Third Avenue
New York, NY 10022
(212) 832-3200

Natural Resources Defense Council
122 E. 42nd St.
New York, NY 10168
(212) 949-0049

Sierra Club
530 Bush St.
San Francisco, CA 94108
(415) 981-8634

The following national organizations are working on groundwater issues:

Environmental Action Foundation
724 DuPont Circle Building
Washington, DC 20036
(202) 659-9682

Environmental Law Institute
1346 Connecticut Ave., N.W. #600
Washington, DC 20036
(202) 452-9600

Environmental Policy Institute
218 D St., S.E.
Washington, DC 20003
(202) 544-2600

National Wildlife Federation
1412 16th St., N.W.
Washington, DC 20036
(202) 797-6800

For information and activities concerning water issues in your state or region contact your state Citizen Action Group or Coalition, Environmental Council or Public Interest Research Group, often located in the state capital, or your soil and water conservation district, or the following citizen and environmental organizations:

Arizona
Southwest Environmental Service
P.O. Box 2231
Tucson, AZ 85702
(602) 624-2353

Arkansas
National Water Center
Box 548
Eureka Springs, AR 72632
(501) 253-9431

California
Silicon Valley Toxics Coalition
361 Willow Street
San Jose, CA 95110
(408) 998-4050

Colorado
Western Organization Resource Council
P.O. Box 1742
Montrose, CO 81402

Florida
Environmental Service Center
916 E. Park Ave.
Tallahassee, FL 32301
(904) 222-0433

Georgia
The Georgia Conservancy
4405 Paulsen Street
Savannah, GA 31405
(914) 234-1628

Hawaii
Hazel Cunningham
3011 Oahu Avenue
Honolulu, HI 96822

Illinois
Citizens for a Better Environment
59 East VanBuren Street
Suite 1600
Chicago, IL 60605
(312) 939-1530

Indiana
Citizens Action Coalition
311 West Washington #303
Indianapolis, IN 46204

Kansas
Kansas Natural Resource Council
P.O. Box 2128
Topeka, KS 66603

Louisiana
Ecology Center
Box 19146
New Orleans, LA 70179

Maine
Maine Natural Resource Council
51 Chapel Street
Augusta, ME 04330

Michigan
West Michigan Environmental Action Council
1324 Lake Drive, SE
Grand Rapids, MI 49506
(616) 451-3051

Missouri
Coalition for the Environment
6267 Delmar
St. Louis, MO 63123
(314) 727-0600

Montana
Mountain Environmental Information Center
P.O. Box 1184
Helena, MT 59624

Nebraska
Center for Rural Affairs
P.O. Box 736
Hartington, NE 68739

New Jersey
Passaic River Coalition
246 Madisonville Road
Basking Ridge, NJ 07920

New Mexico
Southwest Research and Information Center
P.O. Box 4524
Albuquerque, NM 87194
(505) 262-1862

New York
Group for the South Fork
Box 569
Bridgehampton, NY 11932
(516) 537-1400

North Carolina
Conservation Council of N. Carolina
307 Granville Road
Chapel Hill, NC 27514
(919) 942-7935

North Dakota
Dakota Resource Council
Box 254
Dickinson, ND 58601

Oregon
Oregon Environmental Council
2637 W. Water Avenue
Portland, OR 97201

Vermont
Vermont Natural Resource Council
26 State Street
Montpelier, VT 05602

Washington
Four Creeks Community Association
Box 508
Chimacum, WA 98325

Wisconsin
Wisconsin's Environmental Decade
114 N. Carroll St.
Madison, WI 53703
(608) 251-7020

Wyoming
Powder River Basin Resource Council
48 North Main Street
Sheridan, WY 82891
(307) 672-5809

Other interested individuals and citizen groups can be located by contacting CONCERN, Inc. 1794 Columbia Rd. N.W., Washington, DC, 20009, (202) 328-8160.

State Groundwater Contacts

Alabama
Joe Alan Power
Water Supply Program
Department of Environmental Management
State Capitol
Montgomery, AL 36130
(205) 261-5667

Alaska
Dick Farnell
Dept. of Environmental Conservation
Pouch O
Juneau, AK 99881
(907) 465-2653

Arizona
Bob Munari
Bureau of Water Quality Control
Dept. of Health Services
1740 West Adams Street
Phoenix, AZ 85007
(602) 255-1254

Arkansas
Benjamin Saltzman
Arkansas Department of Health
4815 West Markham
Little Rock, AR 72201
(501) 661-2111

California
Peter Rogers
Dept. of Health Services
714 P Street
Sacramento, CA 95814
(916) 324-2207

Colorado
Rick Karlin
Water Quality Division
Dept. of Health
4210 East 11th Avenue
Denver, CO 80220
(303) 320-8333

Connecticut
Ray Jarema
Water Supplies Section
Conn. Dept. of Health
79 Elm Street
Hartford, CT 06145
(203) 566-1253

Delaware
Richard B. Howell
Division of Public Health
Jesse Cooper Memorial Bldg.
Dover, DE 19901
(302) 736-4731

Florida
Al Bishop
Bureau of Water Management
Dept. of Environmental Regulation
2600 Blair Stone Road
Tallahassee, FL 32301
(904) 488-9560

Georgia
Gene B. Welsh
Dept. of Natural Resources
Water Protection Branch
270 Washington Street SW
Atlanta, GA 30334
(404) 656-6593

Hawaii
M.K. Koizumi
Environmental Health
Hawaii Dept. of Health
P.O. Box 3378
Honolulu, HI 96801
(808) 548-4139

Idaho
Larry Koenig
Division of Environment
Dept. of Health & Welfare
State House
Boise, ID 83720
(208) 334-4255

Illinois
Ira Markwood
Illinois Environmental Protection Agency
Public Water Supply Division
2200 Churchill Road
Springfield, IL 62706
(217) 782-9470

Indiana
C. Neil Ott
Div. Public Water Supply
Indiana State Board of Health
1330 W. Michigan Street
Indianapolis, IN 46206
(317) 633-0174

Iowa
Keith Bridson
Water, Air, & Waste Management
Wallace State Office Building
Des Moines, IA 50319
(515) 281-8935

Kansas
Gyula Kovach
Bureau of Water Protection
Div. of Environment
Kansas Dept. of Health & environment
Forbes Field, Bldg. #740
Topeka, KS 66620
(913) 862-9360

Kentucky
Division of Water Quality
Dept. of Natural Resources & Environmental Protection
18 Reilly Road, Ft. Boone Plaza
Frankfort, KY 40601
(502) 564-3410

Louisiana
Sarah Braud
LA Dept. of Health and Human Resources
P.O. Box 60630
New Orleans, LA 70160

Maine
Clough Topan
Drinking Water Program
Div. of Health Engineering
Dept. of Human Services
157 Capital Street
Augusta, ME 04333
(207) 289-3826

Maryland
William Parrish
Division of Water Supply
Dept. of Health & Mental Hygiene
201 W. Preston Street
Baltimore, MD 21201
(301) 383-4249

Massachusetts
M. Ilyas Bhatti
Div. of Water Supply
Dept. of Environmental Quality Engineering
One Winter Street
Boston, MA 02108
(617) 292-5500

Michigan
William Kelley
Water Supply Division
Department of Public Health
3400 N. Logan
PO Box 30335
Lansing, MI 48909
(517) 373-1376

Minnesota
Gary Englund
Health Department
717 Delaware Street, NW
Minneapolis, MN 55440
(612) 296-5330

Mississippi
James McDonald
Bureau of Environmental Health
Water Supply Division
Jackson, MS 39209
(601) 354-6616

Missouri
William C. Ford
Dept. of Natural Resources
Division of Environmental Quality
Public Drinking Water Program
PO Box 1368
Jefferson City, MO 65102
(314) 751-3241

Montana
Dan Fraser
Water Quality Bureau
Dept. of Health & Environmental Sciences
Cogswell Building
Helena, MT 59620
(406) 449-2406

Nebraska
Clifford Summers
Div. of Environmental Engineering
Nebraska Dept. of Health
PO Box 95007
Lincoln, NE 68509
(402) 471-2674

Nevada
James Maston
Public Health Engineering
Nevada State Health Division
505 E. King Street
Carson City, NV 89710
(702) 885-4750

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